


# Trends in Hip Replacements Between 1999 and 2012 in Sweden

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**ABSTRACT:** National Registers document changes in the circumstance, practice, and outcome of surgery with the passage of time. In the context of total hip replacement (THR), registers can help elucidate the relevant factors that affect the clinical outcome. We evaluated the evolution of factors related to patient, surgical procedure, socio-economy, and various outcome parameters after merging databases of the Swedish Hip Arthroplasty Register, Statistics Sweden and the National Board of Health and Welfare. Data on 193,253 THRs (164,113 patients) operated between 1999 and 2012 were merged. We studied the evolution of surgical volume, patient demographics, socio-economic factors, surgical factors, length-of-stay, mortality rate, adverse events, re-operation and revision rates, and Patient Reported Outcome Measures (PROMs). Throughout this time period the majority of patients were operated on with a diagnosis of primary osteoarthritis. Comorbidity indices increased each year observed. The share of all-cemented implants has dropped from 92% to 68%. More than 88% of the bearings were metal-on-polyethylene. Length-of-stay decreased by 50%. There was a reduction in 30- and 90-day mortality. Re-operation and revision rates at 2 years are decreasing. The post-operative PROMs improved despite the observation of worse pre-operative pain scores getting over time. The demographics of patients receiving a THR, their comorbidities, and their primary diagnosis are changing. Notwithstanding these changes, outcomes like mortality, re-operations, revisions, and PROMs have improved. The practice of hip arthroplasty has evolved, even in a country such as Sweden that is considered to be conservative with regard taking on new surgical practices. © 2017 The Authors. *Journal of Orthopaedic Research*® Published by Wiley Periodicals, Inc. on behalf of Orthopaedic Research Society. *J Orthop Res* 36:432–442, 2018.

**Keywords:** trends; total hip replacement; register

When Sir John Charnley developed his “low friction arthroplasty” in the early 1960s, he did so using the technology and materials available at that time<sup>1</sup> and continually developed surgical practices to improve the operation. Since then, the original Charnley implant, the gold standard for many years, has been superceded with the use of other types of cemented implants and prostheses that do not rely on cement for fixation. Details of the surgical procedure as well as the perioperative treatment of patients have changed dramatically. Today the standard 10-year survival rates in the majority of patient groups being operated upon can be expected to be greater than 95%.<sup>2</sup> The main objective of THR is to relieve pain and improve function, now measured with increasing sophistication with the development of a range of patient-reported outcome measures (PROMs). These measures of clinical improvement are now collected in addition to the traditional markers for success of a surgical intervention such as death, radiographic evaluations, and/or revision rates.<sup>3–7</sup>

In the beginning of the 20th century, Codman developed Registers as part of the assessment of outcomes using principles such as the “End Result Idea.” As health care Registers have evolved their utility has become appreciated by surgeons, implant companies, patients, and by those who make decisions on the provision of health care.<sup>8</sup> The Swedish Hip Arthroplasty Register (SHAR) was set up in 1979, initially to study revision procedures. Gradually over the years there have been changes in the content and the methods of data collection and greater ambition for use of the Register as a tool to improve the outcome for patients.<sup>9</sup> The SHAR belongs to the group of the Swedish Quality Registers (QR). The collection of patient-reported outcomes is becoming standard practice in the QR’s in Sweden and is used for quality improvement purposes.<sup>10</sup>

The existence of a unique Personal Identity Number (PIN) in the Scandinavian countries is a prerequisite for merging SHAR data with other databases governed by the National Board for Health and Welfare (Socialstyrelsen) and Statistics Sweden (SCB). These databases contain socio-economic, mortality, and medical data.<sup>11</sup>

There is currently an increased interest in research based on register data as it contains a wealth of information on large numbers of patients that would be difficult to obtain using the more classical ways of research.<sup>12–14</sup> The pearls and pitfalls of Big Data have recently been reported by Patel et al.<sup>15</sup> and there are many concerns about the potential for misinterpretation

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of the data.<sup>16–18</sup> There has, however, been an emergence of local, national, and international databases as well as an increased collaboration between the different databases.<sup>19</sup> Using the data provided with these merged databases, associations between different patient and procedural related characteristics can provide information which might well lead to a better understanding of factors influencing outcomes and subsequently to the construction of a shared decision-making tool.

From the beginning, it was the aim of the SHAR to provide feedback to the providers of patient care. Despite governmental funding, ownership of the SHAR has remained with the orthopaedic surgeons and its leadership has ensured that data was appropriately collected, validated, and clean to be able to provide the feedback. Over the years, the feedback to the surgeons and healthcare providers has been provided by the introduction of the standardized yearly reports and subsequently by in-depth analyses of selected patient groups, implant types, or procedures.

We aim to analyze the Registry data collected prospectively in the period between 1/01/1999 and 31/12/2012 to study the trends in patient- and procedure-related factors with inclusion of socio-economic and medical data. This has been achieved by combining the databases of SHAR and the relevant parts of those administered by the National Board of Welfare and Health and Statistics Sweden. Focus during this work will be on the evolution in performed surgical procedures, number, hospital type, and surgical characteristics, changes in demographics, influence of socio-economic factors and comorbidities, re-operations and revisions, mortality rate and patient-reported outcomes.

## METHODS

### Study Design

This study is a level 2C observational outcome study<sup>20</sup> using the data on THR's from the SHAR. In total there were 193,253 THRs performed in 164,113 patients. The unique PIN was used to merge data on all primary THR between 1999 and 2012 in the SHAR with person-related information available from Statistics Sweden and the National Board for Health and Welfare. The resulting new database is stored and accessible on an encrypted SODA (Secure On-Line Data Access) network.<sup>11</sup> The SHAR uses both a paper and electronic version to collect patient-related and procedure-related characteristics.<sup>9</sup> The type and different levels of data used for this analysis are part of the standard data set for registries as agreed by international registry collaborations.<sup>6</sup> For this analysis, we have used following characteristics (Table 1). All the patient-related data, such as PIN, sex, laterality, indications for implantation, and surgery-related data (approach, fixation method) are registered prospectively as part of a nationwide validated observational program using a standardized computer form.

During the collection period it became the practice to prospectively collect additional datasets such as PROMs. PROMS data collection was started in 2002 but was gradually adopted and became nationwide 2008.<sup>5</sup> All patients are asked to complete a pre-operative questionnaire using self-reported

Charnley classification,<sup>5,21</sup> EQ-5D-3L, EQ VAS, and pain VAS.

The self-reported Charnley classification is based on answers to two standard questions and consists of three levels; A being unilateral hip disease, B being bilateral hip disease, and finally C being multiple joint disease or some major medical condition impairing walking ability.<sup>5</sup> EQ-5D-3L is a validated measurement of the health-related quality of life (HRQoL) and evaluates mobility, self-care, usual activities, pain/discomfort, and anxiety/depression and has three levels of severity, total calculated values are ranging between  $-0.594$  (a state worse than death) and  $1.0$  (best state). EQ VAS (Visual Analogue Scale) is an assessment of general health ranging between  $0$  (worst possible health state) and  $100$  (best possible health state). VAS for pain is ranging from  $0$  (absence of pain) to  $100$  (worst pain imaginable). Pre-operatively, at 1, 6, and 10 years following surgery patients are mailed and asked to complete the same questionnaire.

Finally, the linking process to Statistics Sweden made it possible to add additional socio-economic data such as information about income and level of education. We decided to analyze the average income of all the patients undergoing a THR in every calendar year and record the highest level of achieved education, dividing it in three levels (low, medium, and high) depending on the number of years education the patients succeeded. The data variables available for the research and the linkage process have been described previously and have been stored in an anonymized research database.<sup>11</sup>

### Statistical Analysis

We used the R3.2.2 computing environment for statistical analyses and data visualization. Continuous variables were summarized as means and standard deviations, categorical variables as percentages, and absolute numbers. We used robust and non-parametric regression for trend analyses. The outcome for the regression analyses was the variable of interest and this was regressed on calendar year.

### Ethical Board Approval

Ethical approval was requested and approved by the Regional Ethical Review Board in Gothenburg (entry number: 430-15 dated 8/06/2015 and 271-14 dated 9/04/2014).

## RESULTS

### Volumes and Prevalence

The numbers of primary THR increased from 10,552 per year in 1999 to 15,945 in 2012 as reported to the SHAR. This indicates a more than 50% increase over the 14 years within the cohort. The biggest increase happened between 2008 and 2009, as a result of a government driven initiative to decrease the waiting time before surgery, thereafter numbers stabilized around 16,000 per year (Fig. 1, 5–10). The number of living patients with bilateral hips has increased from 6.6% in 1999 to 11.8% in 2012. Prevalence of patients having hip replacements is represented in Table 2.

### Patient Factors

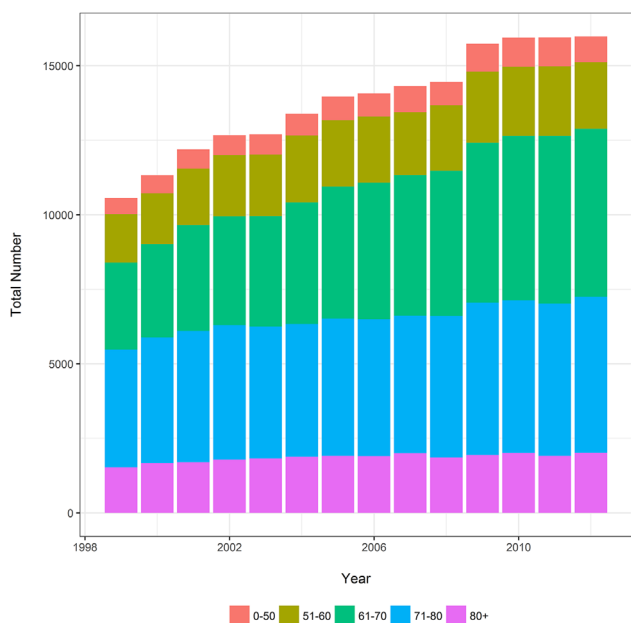
The mean age at the time of surgery decreased slightly from 69.5 (SD 11.0) in 1999 to 68.8 (SD 10.5) in 2012.

**Table 1.** Patient- and Surgery-Related Data and the Level and Source of the Data (\*From the National Board for Health and Welfare and ^From Statistics Sweden, Unmarked From the SHAR)

	Level 1	Level 2	Level 3
Patient-Related	Sex Age Indication for implantation Death	Comorbidities* BMI ASA score	PROMs Socio-economic data ^
Procedure-Related	Date of surgery Type of procedure  Hospital identification Re-operation/revision	Surgical technique Approach Fixation method Head size Bearing couple	

We have included a distribution age trend in grouped age ranges in Figure 1. The predominance of the female gender is decreasing over the years (Fig. 2).

The comorbidity scores as measured by Charlson Comorbidity Index (CCI) as well as the Elixhauser comorbidity index are showing that the amount of comorbidities in the patients undergoing THR is increasing year on year (Fig. 3). Comorbidities such as diabetes increased and the share of patients with inflammatory arthritis decreased during the period of observation. The amount of patients with diagnosed alcohol-related problems and depression doubled. As a reflection of the increasing share of patients operated with comorbidities, the American Society of Anaesthesiologists (ASA) score, recorded since 2008, show an increasing share of patients classified with ASA>2 and ASA>3 (Fig. 4).



**Figure 1.** Distribution trends in age ranges at the time of surgery in Sweden.

We are seeing a minor though significant increase in Body Mass Index (BMI). However, we are aware that some data at the start of the study period was limited and missing. The data represented as a consequence will only start in 2008 (Fig. 5).

Primary OA of the hip is as expected the most common diagnosis during the entire period. Its relative share has increased from 76.7% to 83.0%. Inflammatory arthropathy as an indication for the THR has both decreased in absolute numbers as well as in share from 4.0% in 1999 to 1.2%. THR in acute hip fractures and complications after osteosynthesis has increased in absolute numbers but the share has gone down from 12.9% to 9.5%. The total number of THR for diagnosis of tumor has remained the same within Sweden (Fig. 6).

The average income of patients undergoing hip replacement surgery every year is increasing with exception of 2002 and 2008 where there was a drop. Overall the average income has gone up 184% between 1999 and 2012 (SEK 121,500–224,100). If we consider consumer price index (CPI) adjustment there has been a rise of 152% (147,909–224,100). During the same period, the educational level has increased with more patients having completed high school (middle educational level) or University and graduate class (high level) (Fig. 7).

Seventy-five percent of the hip operations in Sweden are carried out on Monday, Tuesday, and Wednesday with Friday (4–5%) being the least productive day. Surgery at the weekend was infrequent. The proportion of hip surgery performed in University hospitals has seen a continuous drop from 16% to 9%, whereas THR activity in the private sector has increased from 8% to 19%, as result of the government drive to reduce waiting times. The share performed in both rural and county hospitals has overall remained constant.

**Surgical Technique**

With regards to surgical technique there is in Sweden an evolution away from the direct-lateral approach

**Table 2.** Prevalence of Patients With at Least 1 Hip Replacement During the Study Period 1999–2012

Absolute numbers		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
<40		539	582	634	682	724	757	766	783	820	828	835	862	867	851
40–49		1,414	1,459	1,599	1,700	1,838	2,001	2,223	2,330	2,465	2,594	2,772	3,040	3,252	3,285
50–59		5,767	6,372	6,920	7,439	7,864	8,222	8,499	8,707	8,881	9,142	9,526	9,854	10,318	10,666
60–69		13,267	14,570	15,944	17,473	18,999	20,806	22,944	24,899	26,735	28,353	30,031	31,559	33,061	33,955
70–79		23,941	25,564	27,458	29,375	31,067	32,882	34,539	36,396	38,334	40,303	42,639	44,600	46,486	49,054
80–89		15,340	18,100	20,714	22,994	25,128	27,145	29,292	31,052	32,560	34,045	35,563	36,976	38,218	39,660
90+		1,669	2,093	2,495	2,937	3,433	3,911	4,325	4,874	5,481	5,943	6,471	7,350	8,226	8,756
Total		61,937	68,740	75,764	82,600	89,053	95,724	102,588	109,041	115,276	121,208	127,837	134,241	140,428	146,227

Prevalence per 100,000 person		12	13	14	15	16	17	17	17	18	18	18	19	19	18
<40		120	125	137	145	156	166	182	188	196	204	216	235	249	249
40–49		477	517	555	595	632	670	703	729	752	783	821	852	890	916
50–59		1,633	1,775	1,909	2,026	2,107	2,195	2,309	2,400	2,482	2,550	2,636	2,716	2,812	2879
60–69		3,349	3,652	3,993	4,321	4,639	4,961	5,249	5,526	5,782	6,014	6,246	6,439	6,566	6,681
70–79		4,107	4,672	5,215	5,734	6,198	6,629	7,091	7,489	7,864	8,201	8,582	8,993	9,362	9,746
80–89		2,651	3,212	3,724	4,287	4,869	5,369	5,839	6,447	7,125	7,622	8,091	8,572	9,139	9,598
90+		699	774	850	924	992	1062	1,134	1,197	1,255	1,309	1,369	1,426	1,481	1,530

with patients supine from 19% to 5% and move toward lateral approach in lateral decubitus from 18% to 42% with the posterior approach slowly losing ground from 63% to 51%. More than 93% of the patients undergo their surgery being positioned in lateral decubitus, an increase from 81%.

**Fixation**

Fully cemented hips have traditionally been the mainstay of treatment in Sweden although the share has diminished over the years from 92% in 1999 to 68% in 2012. In the same period, the share of uncemented has gone up from 2% to 16% with the biggest increase between 2005 and 2008. Reverse hybrid implants have seen a similar rise from 1% to 14%. In contradistinction to the practice in many countries, conventional hybrid THR's have been used very infrequently in Sweden (Fig. 8). Resurfacing implants have never been implanted in great numbers and their use peaked between 2005 and 2008 at less than 2%.

**Bearings**

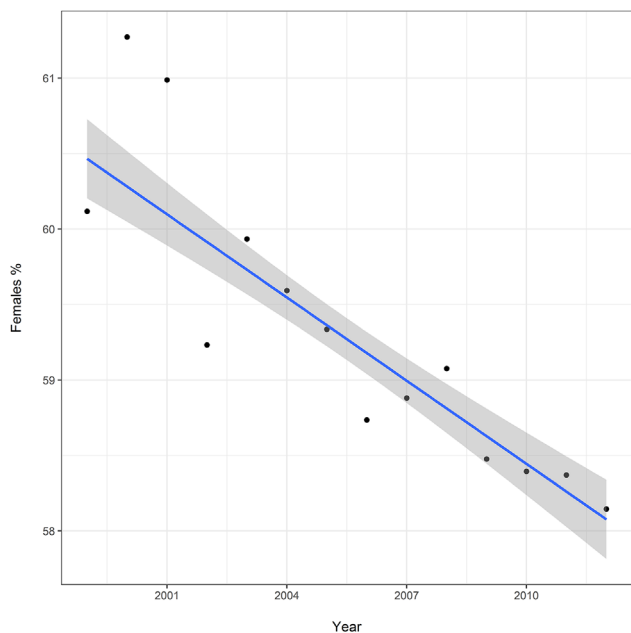
Metal-on-polyethylene has been used in the majority of hip replacements (86%) with a movement toward cross-linked polyethylene since 2008. Of the hard-on-hard bearings, the use of metal-on-metal (resurfacing and conventional) peaked in 2008 at 2% but use of this pairing is almost obsolete since 2010. Ceramic-on-ceramic is hardly used in Sweden (<1%), but the use of a hard-on-soft ceramic-on-polyethylene bearing has increased from 7% in 1999 to 12% in 2012 (Fig. 9). During the study period, we have identified a shift in 2010 from 28 mm heads in the majority of cases to >32 mm. In 2012, 32 mm heads accounted for 62% of implants (Fig. 10).

**Revisions and Other Re-operations**

In the SHAR revisions are classified as an operation where there is an exchange or removal of any of the components, whereas a re-operation is per definition all revisions and all other hip-related operations. The 2-year re-operation and revision rates are improving, however there seems to be an increase in early (30- and 90-day) re-operation and revision rates, this increase started to occur around 2002 (Figs. 11 and 12). The main reasons for re-operations at 30 and 90 days have shown a change in pattern. Nowadays infection is the primary cause for re-operation and there has been an increase in re-operations for both infection as well as fractures, with the numbers of re-operations for dislocation decreasing (Figs. 13 and 14).

**Mortality**

The 90-day mortality has reduced from 1.1% to 0.7% in the time period with the absolute number

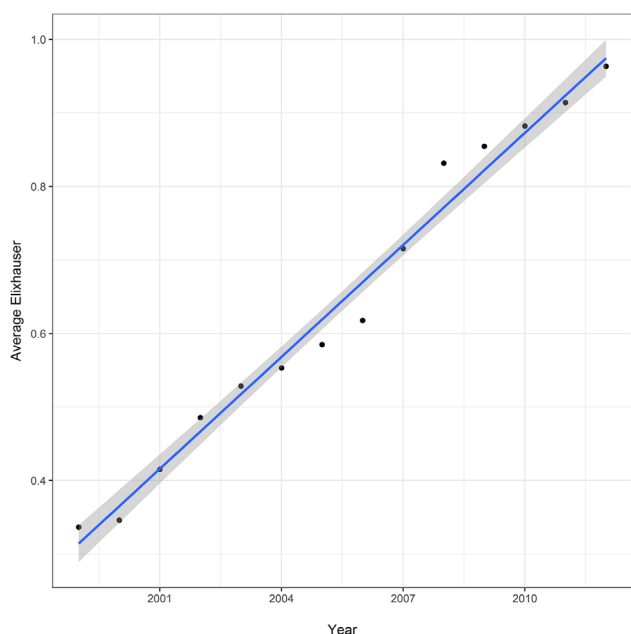


**Figure 2.** Gender predominance in the years 1999–2012.

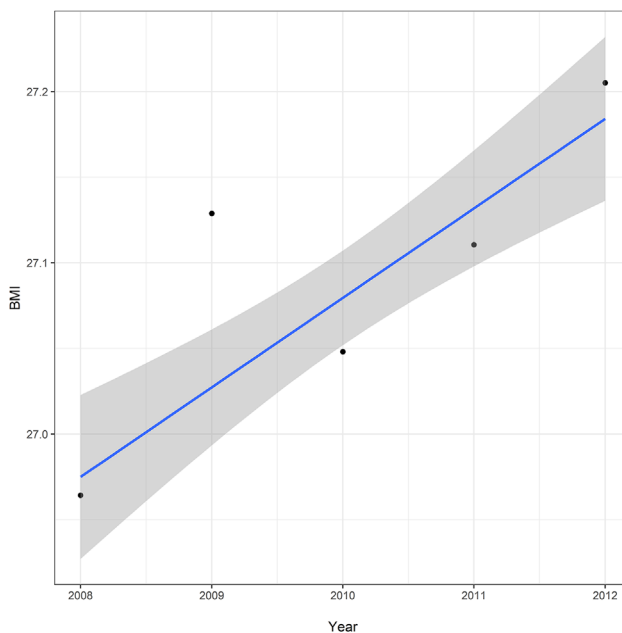
remaining the same with a 50% increase in number of operations. The 30-day mortality has largely followed the same trends (Fig. 15).

**Patient-Reported Outcomes**

As the PROMs program was initiated in 2002, data is only available from that point onwards and reached nationwide extent in 2008 with 86% completeness.<sup>5</sup> The self-reported Charnley classification has remained about constant with the majority of patients declaring that they have unilateral disease or multi joint disease pre-operatively. During the last part of the period

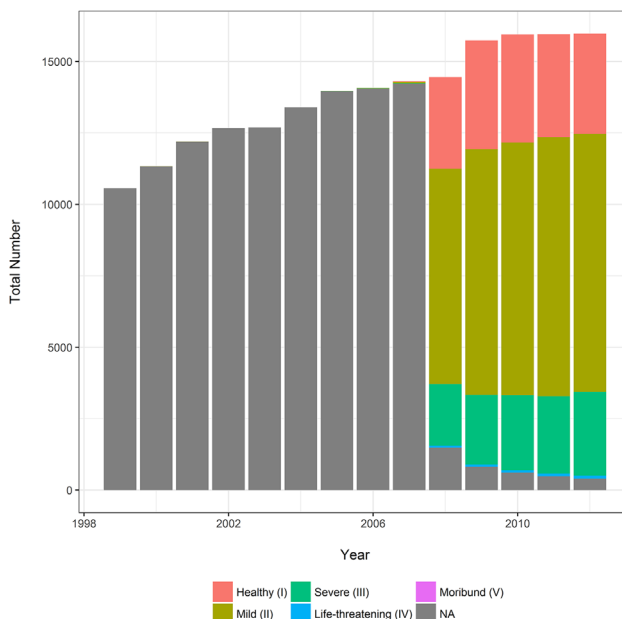


**Figure 3.** Elixhauser comorbidity index per operation year.

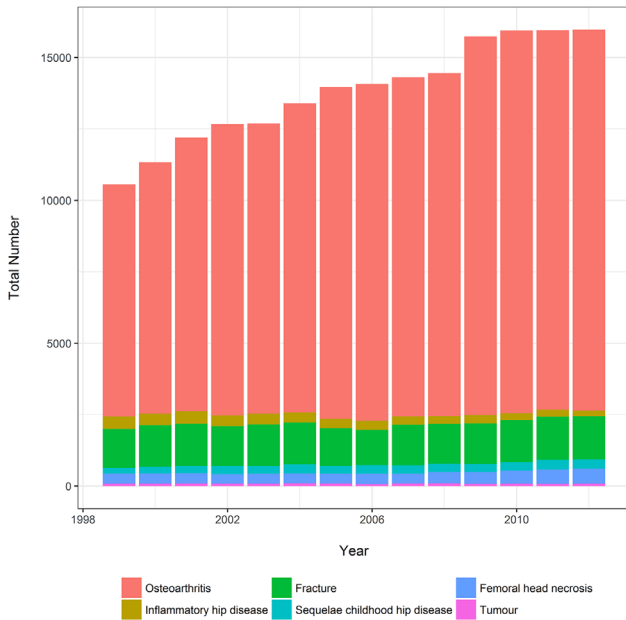


**Figure 4.** Evolution of BMI in THR,(the collection of BMI data was only nationwide since 2008 and therefor could only be considered a reliable representation of the studypopulation since 2008).

studied, the patients undergoing surgery are reporting more pain in the pre-operative period from average of 62.5 in 2008 to 63.5 in 2012, less problems with the EQ-5D, 0.40 to 0.41 and EQ VAS increasing from 53.2 to 57.1 (Figs. 16–18). The post-operative figures are improving with pain reducing from 14.7 to 13.8, EQ-5D improving from 0.77 to 0.78, and EQ VAS increasing from 75.1 to 76.1 (Figs. 16–18). The overall patient satisfaction as measured with Satisfaction VAS is



**Figure 5.** Evolution of ASA-scores in THR (only routinely collected since 2008).

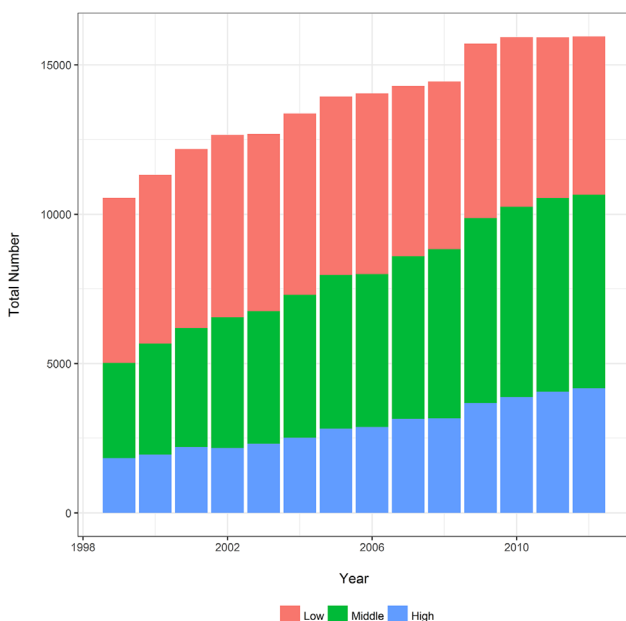


**Figure 6.** Clinical diagnosis at intervention.

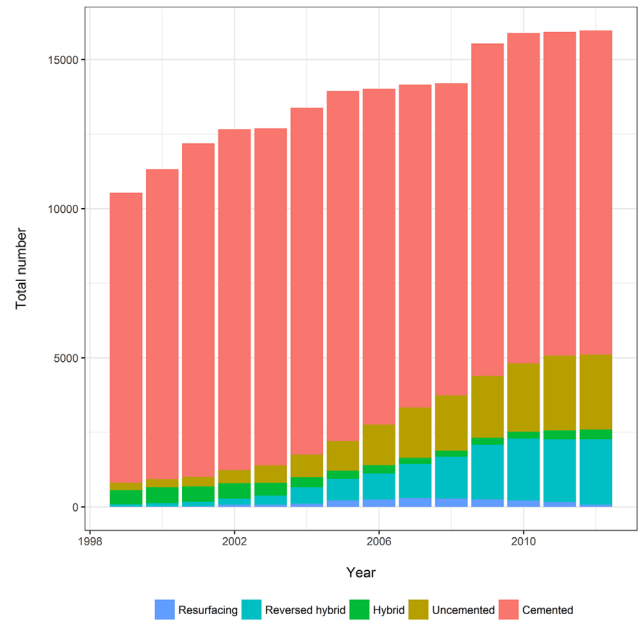
showing increased satisfaction (score between 0 and 20 = extremely satisfied) (Fig. 19).

**DISCUSSION**

Quality registers in Sweden have to publish annual reports of their findings and the yearly reports have been the norm from the SHAR. In addition to the information described in the yearly SHAR report, we have been able to analyze socio-economic data as well as patient-related data for this paper and this is for the first time. Besides a pure description of the trends we endeavor, amongst other important issues, to



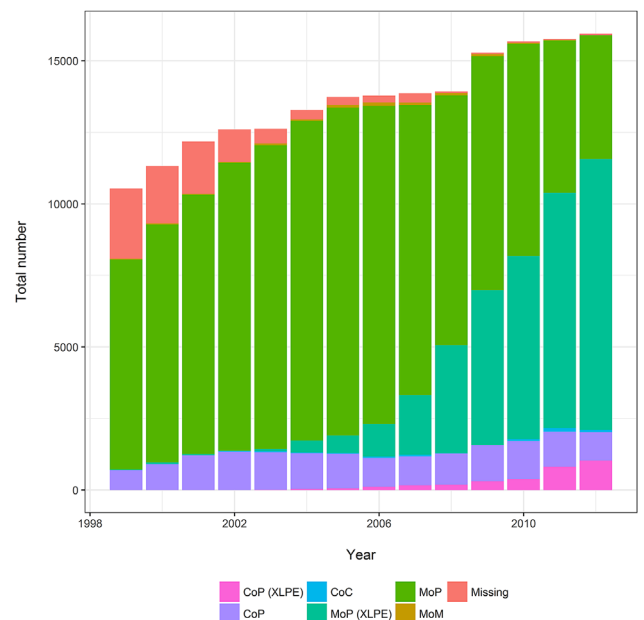
**Figure 7.** Highest achieved level of education.



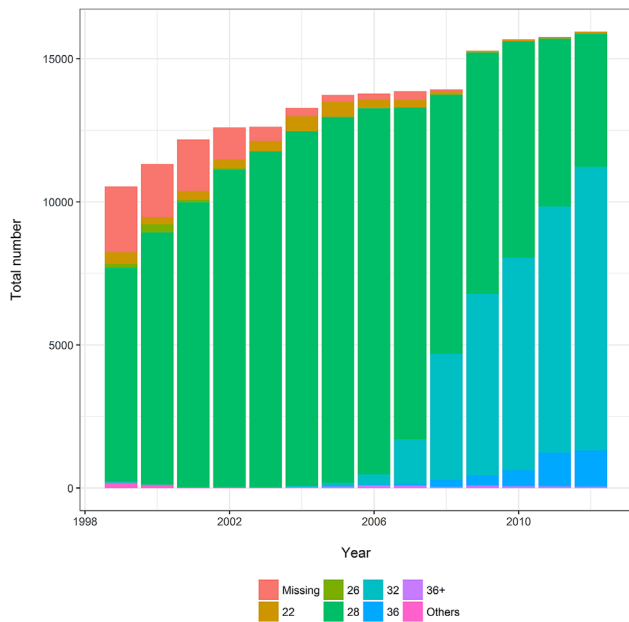
**Figure 8.** Fixation type.

highlight some warning signs about the increase of early revisions, and re-operations.

In the Swedish population there has been a steady increase in total hip replacements performed. An initial sharp rise was observed, most probably resulting from a government drive to deal with waiting list problems. Subsequently a minimal (and negligible) increase in numbers performed per year was observed. This is in contrast with the expectation as published by Kurtz, since after the initial increase, we describe a stabilization in the incidence of THR in recent



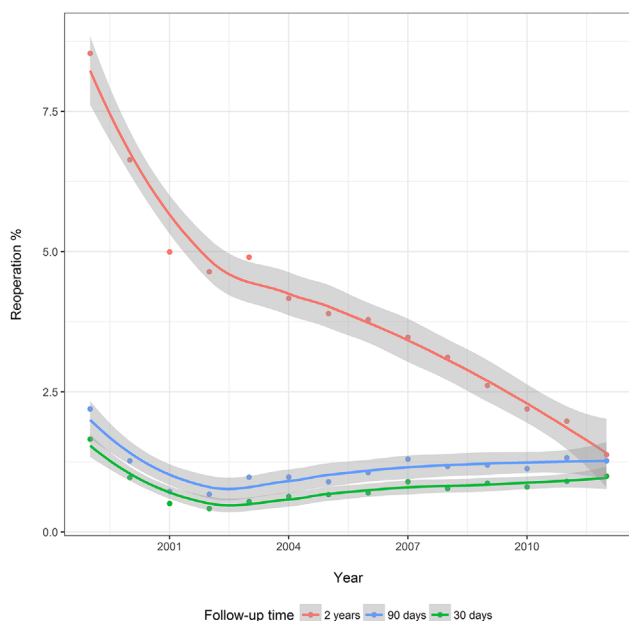
**Figure 9.** Bearing couples used in different years (XLPE = Highly cross-linked poly-ethylene; COP = Ceramic-on-Poly-ethylene; CoC = Ceramic-on-Ceramic; MoP = Metal-on-Poly-ethylene; MoM = Metal-on-Metal).



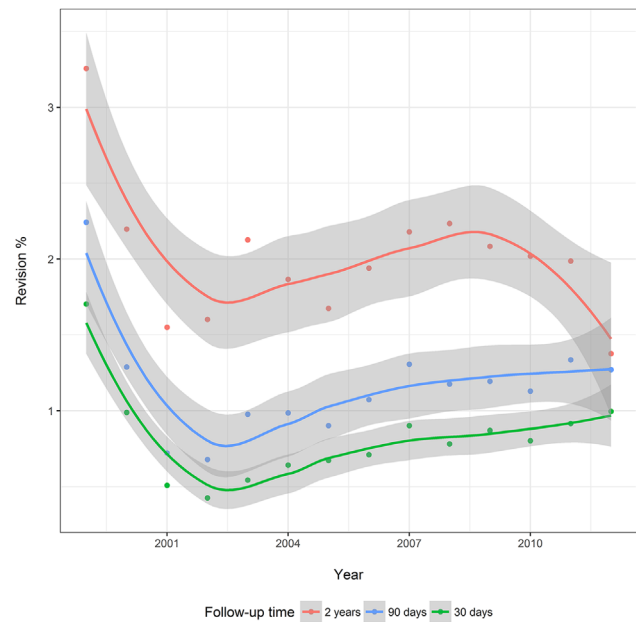
**Figure 10.** Evolution of headsizes.

years.<sup>22–24</sup> The increase in prevalence of patients with THR is most likely to be secondary to the increasing number of younger patients having surgery and the increasing life expectancy. The increase in prevalence, the younger age at the time of surgery, and the consequences of osteoporosis might well have a longer-term consequence, currently not evident, of an increase in revision burden for possibly periprosthetic fractures and infections.

Our data shows that in 2012 hip replacements were performed at an average 0.7 years earlier than in 1999, which is a small change with weak clinical

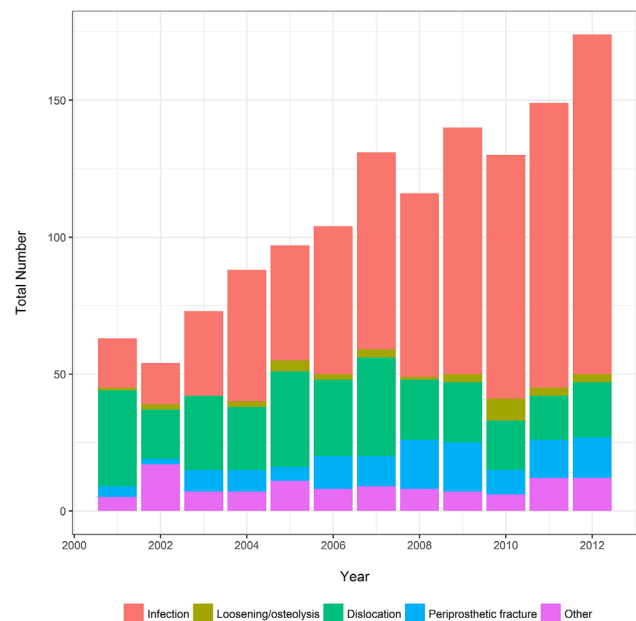


**Figure 11.** Re-operation rate at 30 and 90 days and 2 years.

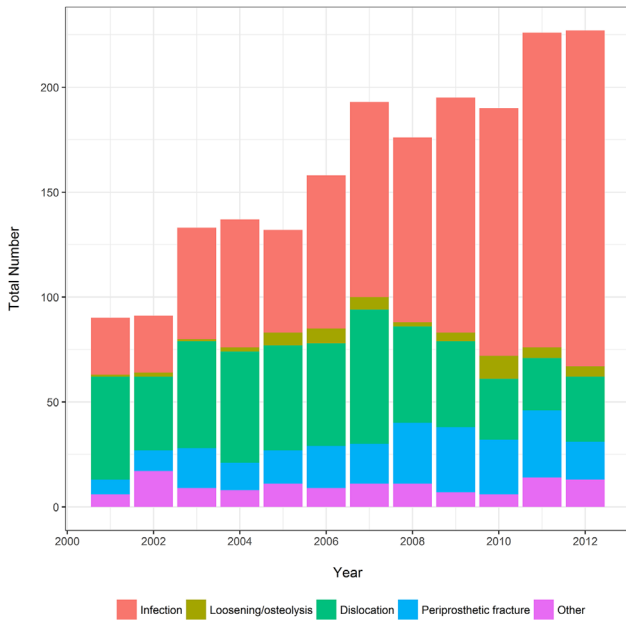


**Figure 12.** Revision rate at 30 and 90 days and 2 years.

significance. This is, however in line with the reports from other countries and might mean that we are operating earlier in the disease process or that younger people present with symptoms (earlier start of the disease process) had enough to warrant surgery. The latter is reflected in our pain VAS findings and we believe we are operating on patients with a higher level of self-reported pain, however without a clinical significant change in self-reported health-related quality of life prior to undergoing the surgery. More patients with multiple comorbidities and high ASA scores undergo surgery. This seems to be a trend



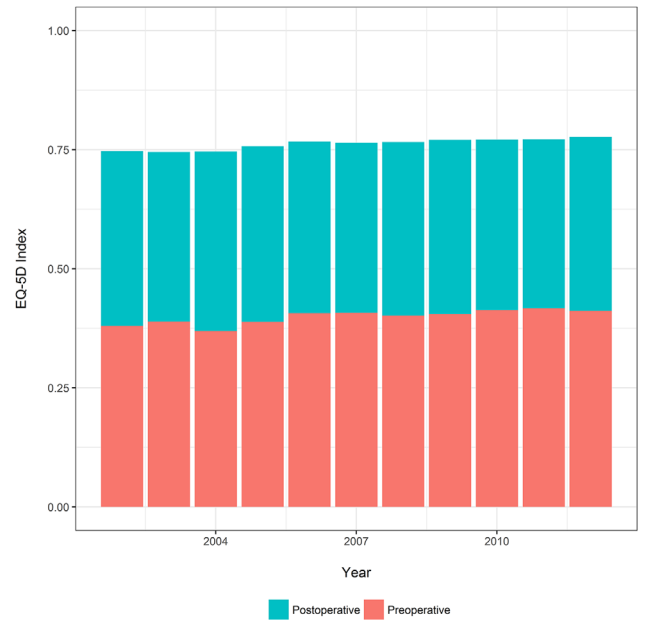
**Figure 13.** Reason for revision at 30 days in absolute figures (data starts in 2000).



**Figure 14.** Reason for revision at 90 days in absolute figures (data starts in 2000).

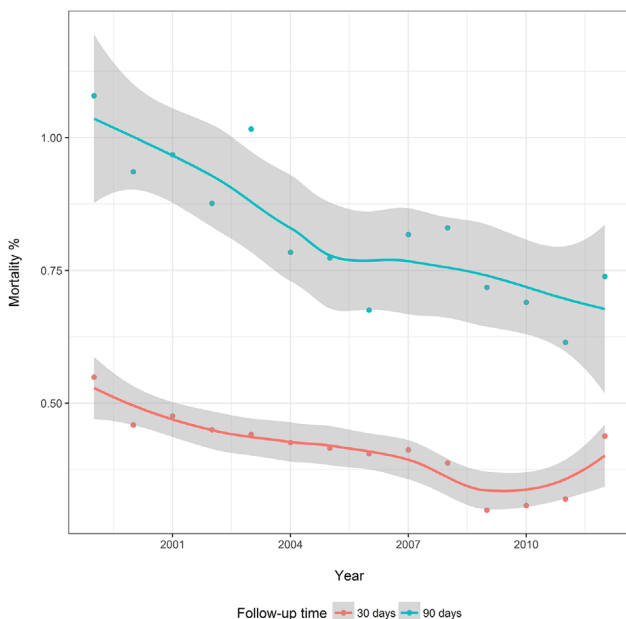
around the developed world and despite the increased medical challenge these patients can cause, the outcome does not seem to be affected. Socio-economic data in the form of average income as well as highest level of education of hip replacements in Sweden is improving. This improvement in socio-economic status has in other studies been linked to better outcomes.<sup>25,26</sup> Whether or not this has an effect on the Swedish patients will be subject to further in depth analysis.

Sweden, always considered as being a conservative country with regards to implant choice has seen a movement away from the traditional all cemented

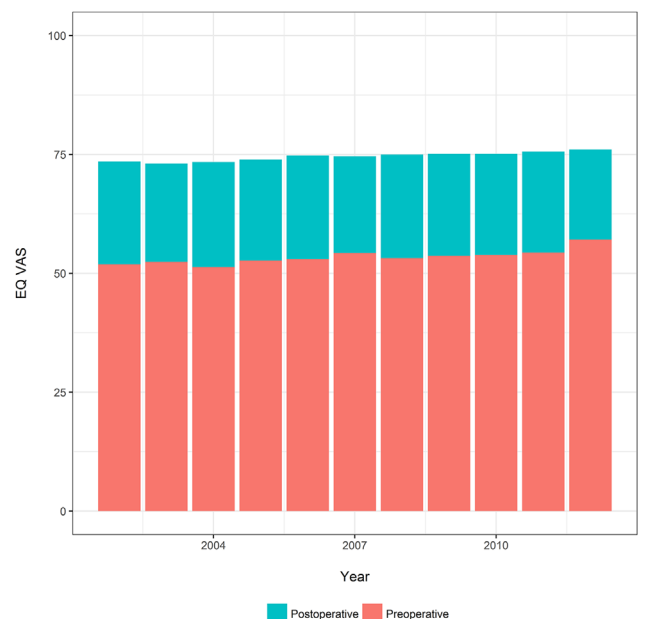


**Figure 16.** EQ-5D pre- and post-operative scores.

implants—mainly in the younger age groups. We believe one of the reasons for this change of fixation choice is the feedback received in the form of the annual reports as issued by the SHAR. The trend away from fully cemented implants toward uncemented implants is discussed in a research paper from the Nordic Arthroplasty Register Association (NARA) in the paper titled the uncemented paradox.<sup>27,28</sup> This change in practice has accelerated in recent years although cemented implants still constitute the majority overall. Whether or not this will have a positive influence on re-operation and revision rates or PROMS

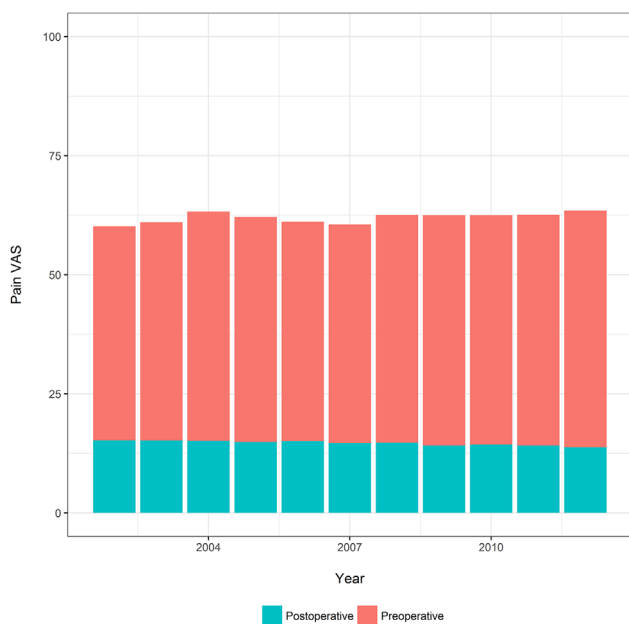


**Figure 15.** A 30- and 90-day mortality.



**Figure 17.** EQ VAS pre- and post-operative.

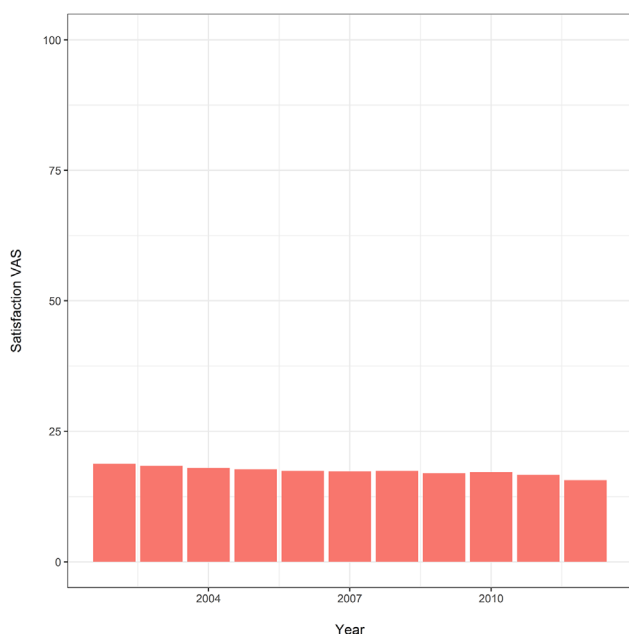




**Figure 18.** Pain VAS pre- and post-operative.

outcomes is not known and cannot be predicted. Compared with other countries there are only a limited numbers of both cemented and uncemented brands implanted. Since 2010, we have observed an increased usage of 32mm heads and XLPE. These changes seem to have an effect on the revision rates due to loosening and dislocation (SHAR report 2015 [<https://registercentrum.blob.core.windows.net/shpr/r/Annual-Report-2015-H19dFINOW.pdf>]) but has to be more firmly defined within the register.

We found decreasing mortality in the early post-operative period (30 and 90 days) similar to other



**Figure 19.** Satisfaction VAS post-operative scores.

publications,<sup>29,30</sup> this despite an increase in comorbidity. The reason for this is likely to be multi-factorial and will certainly include advances in the pre- and peri-operative investigation and care of patients. We do not believe that the reduced average age at the time of operation should be considered as a major influence of decreasing mortality. The introduction of fast-track surgery and the use of VTE prophylaxis might well be more important. Separate studies from the SHAR using the same data have shown an improved long-term patient survival in comparison with a matched (age and gender) population. Further analysis of the reporting of the comorbidity should be performed to ascertain whether the increase in comorbidity is due to a change in reporting and/or a change in reimbursement and that could well be considered a limitation of this study.

There is a slight concern with regards to the small but statistically significant increase in number of early revisions and re-operations since 2002. This seems to be coincidental with the increased usage of uncemented implants in Sweden and increased revisions for fractures in the early post-operative period suggesting a causal relationship.<sup>31</sup> A reason for increasing number of early revisions might be a more aggressive attitude to treat suspected deep infections with debridement, lavage, and change of femoral head/liner, as we have found an increased percentage of early re-operations and revisions, recorded for reason of infection. The second reason for increase for re-operations/revisions is periprosthetic fractures as we have seen an increase in periprosthetic fractures treated surgically in the early post-operative stages. This finding has also been reported by Thien et al.<sup>33</sup> and Pedersen et al.,<sup>32</sup> who described in two studies both from the Nordic Arthroplasty Register Association (NARA) database the association between fixation technique and revision risk and concluded there was an increase of early revisions with use of uncemented fixation.

It will be interesting to perform further long-term review of the patients within the database and see if the life-time risk of revision for Swedish patients following total hip replacements are similar to the ones published by Abdel et al.<sup>34</sup> using multiple and different implants and on a countrywide level. The possible importance of the early re-operations and revisions and its possible importance and impact on the lifetime health risk will be subject for further analysis.

The PROMs program has been an essential part of the data collection within the SHAR, the QR's, and more recently in other national registers.<sup>35,36</sup> Other countries, like the UK and the USA, have commenced using PRO(M)s to define outcomes and quality and those could be used to aid in reimbursement system programs, in reports of performance quality and in negotiations with insurance companies.<sup>4,12,37,38</sup> With increased attention to patient-focused outcome it is interesting to see further improvement of the outcome scores and to observe an

objective signal that the results are improving. We have seen a small improvement in all the recorded PROMs and this is in line with the overall success rate. With a decrease in early mortality, an overall decrease in re-operations, revisions, and length of stay and an improvement in outcome measurements we feel that the outcome of hip replacement surgery is improving. We believe that these improvements are mainly caused by improved care pathways and improved pre-operative and peri-operative management.<sup>39</sup> Further close monitoring, analysis of the failures, and its impact on life time health risk will in our view further improve our understanding and have a potential positive impact on the outcomes. It is however possible that further gains will be depending mainly on patient selection, decision-making, and further improvements of peri-operative care, and be less reliant on implant choice.

It is quite clear that the surgical philosophy and practice in Sweden has been influenced by the work of the registers and its continuous feedback to the profession in the form of the annual reports. Such feedback is in our view the basis and is necessary for reflection and continuous improvement.<sup>40</sup> Use of a more conservative attitude to adopting new implants has led to a reduced revision burden in Sweden compared with other countries more open to unproven innovation.<sup>41</sup> The new implants and techniques that have been adopted have generally been introduced in a relatively stepwise manner.<sup>42,43</sup> The philosophy of “stepwise” change in practice seems to have been adopted in other countries and the UK’s “Beyond Compliance” initiative is an example of how this vision is being further developed. While register-based research cannot prove causality it can provide evidence of our success stories to resist purely marketing-driven or fashion-induced drivers for change.<sup>14</sup>

#### AUTHORS’ CONTRIBUTIONS

Peter Cnudde: Conceived the study, data collection, drafting of the manuscript, editing of the manuscript, and data analysis. Szilard Nemes: Statistical analysis, editing of the manuscript, and data analysis. Erik Bülow: Statistical analysis, editing of the manuscript, and data analysis. John Timperley: Editing of the manuscript and data analysis. Henrik Malchau: Editing of the manuscript and data analysis. Johan Kärrholm: Drafting of the manuscript, statistical analysis, editing of the manuscript, and data analysis. Göran Garellick: Editing of the manuscript and data analysis. Ola Rolfson: Statistical analysis, editing of the manuscript and data analysis. All authors have read and approved the final submitted manuscript.

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